HP435B

OPERATING MANUAL

435B
POWER METER

DUPLICATE OF SECTIONS 1 THRU 3
OF YOUR OPERATING AND SERVICE MANUAL

KEEP WITH INSTRUMENT

Printed JANUARY 1983

HEWLETT PACKARD

HP 435B

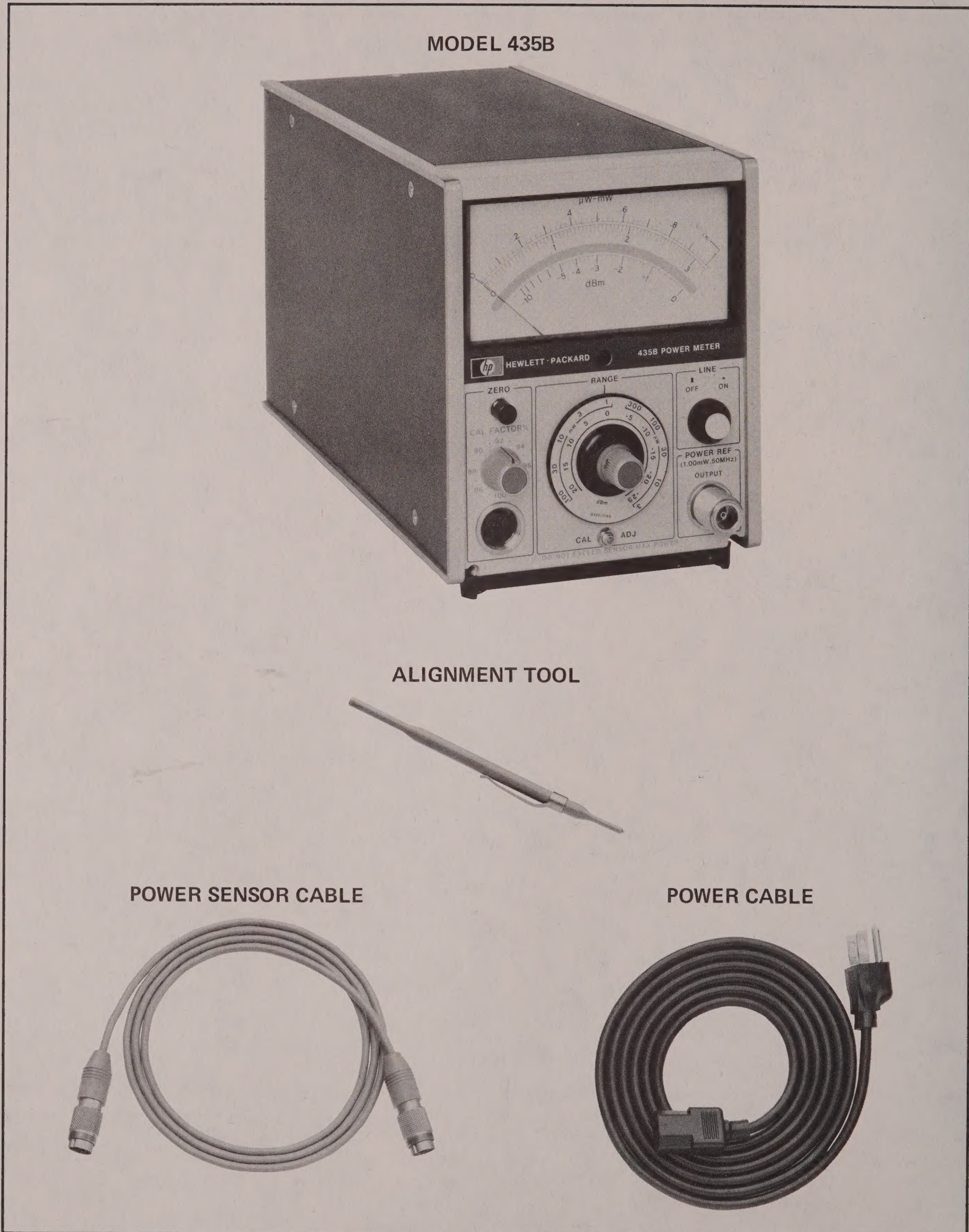


Figure 1-1. HP Model 435B and Accessories Supplied

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION

This manual provides information pertaining to the installation, operation, testing, adjustment and maintenance of the HP Model 435B Power Meter.

Figure 1-1 shows the Power Meter with accessories supplied.

An operating manual is shipped with the instrument. This is simply a copy of the first three sections of this manual. The operating manual should be kept with the instrument for use by the operator. Additional copies of the operating manual may be ordered separately through your nearest Hewlett-Packard office. The part number is listed on the title page of this manual.

On the title page of this manual, below the manual part number, is a "Microfiche" part number. This number may be used to order 100 x 150 mm (4x6-inch) microfilm transparencies of the manaul. The microfiche package also includes the latest Manual Changes supplement as well as all pertinent Service Notes.

Instrument specifications are listed in Table 1-1. These specifications are the performance standards or limits against which the instrument may be tested.

1-2. INSTRUMENTS COVERED BY MANUAL

Options 001, 002, 003, 009, 010, 011, 012 and 013 of the Power Meter are documented in this manual. The differences are noted in the appropriate location such as OPTIONS in Section I, the Replaceable Parts List, and the schematic diagrams.

This instrument has a two-part serial number. The first four digits and the letter comprise the serial number prefix. The last five digits form the sequential suffix that is unique to each instrument. The contents of this manual apply directly to instruments having the same serial number prefix(es) as listed under SERIAL NUMBERS on the title page.

An instrument manufactured after the printing of this manual may have a serial number prefix that is not listed on the title page. This unlisted serial prefix indicates that the instrument is different from those documented in this manual. The manual for this newer instrument is supplied with a yellow Manual Changes supplement that contains "change information" explaining how to adapt the manual to the newer instrument.

In addition to change information, the supplement may contain information for correcting errors in the manual. To keep this manual as current and accurate as possible, Hewlett-Packard recommends that you periodically request the latest Manual Changes supplement. The supplement for this manual is keyed to the manual's print date and part number, both of which appear on the title page. Complimentary copies of the supplement are available from Hewlett-Packard.

For information concerning a serial number prefix not listed on the title page or in the Manual Changes supplement, contact your nearest Hewlett-Packard office.

1-3. DESCRIPTION

The Power Meter and a compatible power sensor are interconnected with the power sensor cable to form a power measurement system. The system power level range, frequency response, and load impedance are dependent on the power sensor.

Accuracy of the power measurement system is ensured by the following Power Meter characteristics:

a. An internal automatic zeroing circuit which removes error due to the ambient temperature output of the power sensor's power sensing device.

b. A calibration factor adjustment which accounts for error due to the frequency response of the power sensing device.

c. An internal calibration reference which has an output of 1 mW ± 0.7% (50Ω).

Table 1-1. Specifications

SPECIFICATIONS

Frequency Range:
100 kHz to 26.5 GHz (depending on power sensor used).

Power Range:
(Meter calibrated in watts and dBm.)
With 8481B or 8482B sensors: 44 dB with 9 full scale ranges of 5, 10, 15, 20, 25, 30, 35, 40 and 45 dBm (1 mW to 25W).
With 8481H or 8482H sensors: 45 dB with 9 full scale ranges of −5, 0, 5, 10, 15, 20, 25, 30 and 35 dBm (30 μW to 3W).
With 8481A, 8482A, 8483A or 8485A sensors: 50 dB with 10 full scale ranges of −25, −20, −15, −10, −5, 0, 5, 10, 15 and 20 dBm (3 μW to 100 mW).
With 8484A sensor: 50 dB with 10 full scale ranges of −65, −60, −55, −50, −45, −40, −35, −30, −25 and −20 dBm (300 pW to 10 μW).

Accuracy:
Instrumentation:[1] ±1% of full scale on all ranges.
Zero: Automatic, operated by front-panel switch.
Zero Set: ±0.5% of full scale on most sensitive range, typical.
Zero Carryover: ±0.5% of full scale when zeroed on the most sensitive range.
Noise (typical, at constant temperature, peak change over any one-minute interval): 20 pW (8484A); 40 nW (8481A, 8482A, 8483A, 8485A); 4 μW (8481H, 8482H); 40 μW (8481B, 8482B).
Drift (1 hour, typical), at constant temperature after 24-hour warm-up); 40 pW (8484A); 15 nW (8481A, 8482A, 8483A, 8485A); 1.5 μW (8481H, 8482H); 15 μW (8481B, 8482B).
Power Reference: Internal 50 MHz oscillator with Type N Female connector on front panel (or rear panel, Option 003 only).

Power output: 1.00 mW.
Factory set to ±0.7% traceable to the National Bureau of Standards.
Accuracy: ±1.2% worst case (±0.9% rss) for one year (0 to 55°C).

Response Time:
(0 to 99% of reading, five time constants.)

Range 1 (most sensitive)	<10.0 seconds.
Range 2	<3.8 seconds.
Range 3	<1.3 seconds.
Ranges 4—10	<500 milliseconds.

Typical, measured at recorder output.)

Cal Factor:
16-position switch normalizes meter reading to account for calibration factor or effective efficiency.
Range 85% to 100% in 1% steps.

Cal Adjustment:
Front panel adjustment provides capability to adjust gain of meter to match power sensor in use.

Recorder Output:
Proportional to indicated power with 1 volt corresponding to full scale; 1 kΩ output impedance; BNC connector.

RF Blanking Output:
Provides a contact closure to ground when auto-zero mode is engaged.

Power Consumption:
100, 120, 220, or 240V +5%, −10%.
100 and 120 volts, 48 to 66 Hz and 360—440 Hz.
220 and 240 volts, 48 to 66 Hz.
20 V·A maximum.

Weight:
Net, 2.7 kg (5.9 lbs).

Dimensions:
155 mm high (6-3/32 inches).
130 mm wide (5-1/8 inches).
279 mm deep (11 inches).

[1] Includes sensor non-linearity. Add +2, −4% on top two ranges when using the 8481A, 8482A, 8483A and 8485A power sensors; add ±4.0% on the top two ranges when using the 8481B and 8482B power sensors; add ±5.0% on the top two ranges when using the 8481H and 8482H power sensors.

1-4. OPTIONS

1-5. Battery

The Model 435B, Option 001 Power Meter is supplied with a rechargeable battery that provides up to 16 hours continuous operation from a full charge.

If the Power Meter was purchased without the battery option, it may be ordered in kit form under HP part number 00435-60012. The kit includes the battery, the battery clamp, a 6-32 x 1/2-inch pan head machine screw and installation instructions.

1-6. Input-Output Options

Option 002. A rear panel input connector is connected in parallel with the front panel input connector.

Option 003. A rear panel input connector replaces the standard front panel input connector; a rear panel POWER REF OUTPUT connector replaces the standard front panel connector.

1-7. Cable Options

A 1.5 metre (5-foot) power sensor cable is normally supplied. The 1.5 metre cable is omitted with any cable option. The option and cable length are shown in the table.

Option	Cable Length in Metres (Ft.)
009	3.1 (10)
010	6.1 (20)
011	15.2 (50)
012	30.5 (100)
013	61.0 (200)

1-8. ACCESSORIES SUPPLIED

The accessories supplied with the Power Meter are shown in Figure 1-1.

a. The 1.5 metre (5-foot) power sensor cable, HP part number 8120-2263, is used to couple the power sensor to the Power Meter. The 1.5 metre cable is omitted with any cable option.

b. The line power cable may be supplied in several configurations. Refer to the paragraph entitled Power Cables in Section II.

1-9. EQUIPMENT REQUIRED BUT NOT SUPPLIED.

To form a complete RF power measurement system, a power sensor, such as the HP Model 8481A, must be connected to the Power Meter via the power sensor cable.

1-10. EQUIPMENT AVAILABLE

The HP Model 11683A Range Calibrator is recommended for performance testing, adjusting and troubleshooting the Power Meter. The Power Meter's range-to-range accuracy and auto-zero operation can easily be verified with the calibrator. It also has the capability of supplying a full-scale test signal for each range.

An extender board (HP part number 5060-0630) may be used to place the A4 assembly printed circuit board in a position that allows easy access to test points and components.

1-11. RECOMMENDED TEST EQUIPMENT

The test equipment shown in Table 1-2 is recommended for use during performance testing, adjustments and troubleshooting. To ensure optimum performance of the Power Meter, the specifications of a substitute instrument must equal or exceed the critical specifications shown in the table.

1-12. SAFETY CONSIDERATIONS

The Power Meter is a Safety Class I instrument (provided with a protective earth terminal). This instrument has been designed according to international safety standards and has been supplied in safe condition.

SECTION II
INSTALLATION

2-1. INTRODUCTION

This section includes information on the initial inspection, preparation for use, and storage and shipment instructions for the Power Meter.

2-2. INITIAL INSPECTION

WARNING

To avoid hazardous electrical shock, do not perform electrical tests when there are signs of shipping damage to any portion of the outer enclosure (covers and panels).

Inspect the shipping container for damage. If the shipping container or cushioning material is damaged, it should be kept until the contents of the shipment have been checked for completeness and the instrument has been checked mechanically and electrically. The contents of the shipment should be as shown in Figure 1-1. Procedures for checking electrical performance are given in Section IV. If the contents are incomplete, if there is mechanical damage or defect, or if the instrument does not pass the electrical performance tests, notify the nearest Hewlett-Packard office. If the shipping container is damaged, or the cushioning material shows signs of stress, notify the carrier as well as the Hewlett-Packard office. Keep the shipping materials for the carrier's inspection.

2-3. PREPARATION FOR USE

2-4. Meter Zeroing

With the LINE switch set to OFF, the meter pointer should be positioned directly over zero. If necessary, insert a screwdriver into the mechanical Meter Zero control (beneath the meter) and align the pointer with zero. Back the adjustment off slightly. The backlash in the control ensures against a meter indication error caused by jarring the instrument.

2-5. Range Switch Scale Selection

The RANGE switch has three scales on 2 removable rings which correspond to the measurement capabilities of compatible power sensors. The range scales are 3W to 0.3 mW (+35 to −5 dBm), 100 mW to 3 μW (+20 to −25 dBm) and 10 μW to 0.3 nW (−20 to −65 dBm). Each scale listed indicates the maximum and minimum full scale meter readings.

To select the correct RANGE switch knob assembly scale (see Figure 2-1):

a. Unscrew the outer (black) knob by turning it counterclockwise. Then, remove the outer knob.

b. Remove the two scale rings.

c. Determine which of the 3 scales is to be used.

d. Place the other scale ring on the knob assembly.

e. Place the selected ring on the knob assembly with the selected scale out.

f. Line up the tabs of the scale rings with the slot in the knob assembly.

g. Hold the scale rings in place with your fingers. Thread the outer knob onto the knob assembly. Lightly tighten the knob.

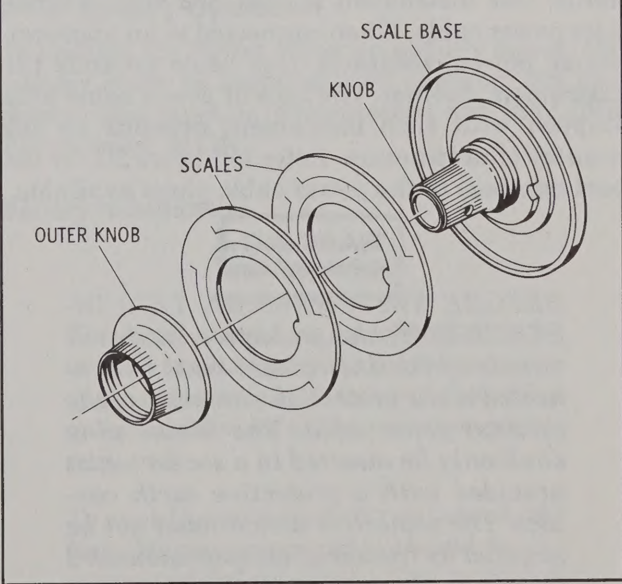


Figure 2-1. Changing Range Switch Scale

2-6. Power Requirements

The Power Meter requires a power source with an output of 100, 120, 220, or 240 Vac +5%, −10% single phase, 100 and 120 volts, 48 to 66 Hz and 360 to 440 Hz, 220 and 240 volts, 48 to 66 Hz. Power consumption is 20 V·A maximum.

WARNING

If this instrument is to be energized via an external autotransformer, make sure the autotransformer common terminal is connected to the earth terminal of the power source.

2-7. Line Voltage Selection

CAUTION

BEFORE SWITCHING ON THIS INSTRUMENT, make sure the instrument is set to the voltage of the power source.

Figure 2-2 provides instructions for line voltage and fuse selection. The line voltage selection card and proper fuse are factory installed for 120 Vac operation.

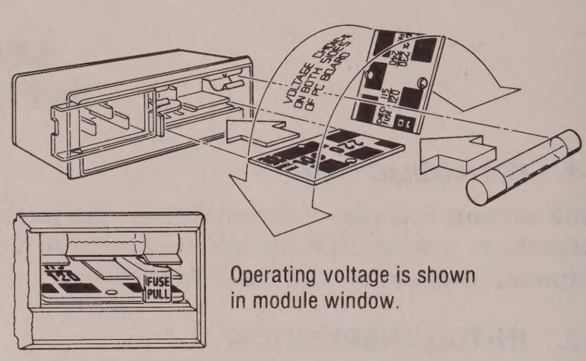
Fuses may be ordered under HP part numbers 2110-0234, 0.1A (250V slow blow) for 100/120 Vac operation and 2110-0040 0.062A (250V slow blow) for 220/240 Vac operation.

2-8. Power Cable

In accordance with international safety standards, this instrument is equipped with a three-wire power cable. When connected to an appropriate ac power receptacle, this cable grounds the instrument cabinet. The type of power cable plug shipped with each instrument depends on the country of destination. Refer to Figure 2-3 for the part numbers of the power cable plugs available.

WARNING

BEFORE SWITCHING ON THIS INSTRUMENT, the protective earth terminals of this instrument must be connected to the protective conductor of the (Mains) power cord. The Mains plug shall only be inserted in a socket outlet provided with a protective earth contact. The protective action must not be negated by the use of an extension cord (power cable) without a protective conductor (grounding).



SELECTION OF OPERATING VOLTAGE

1. Open cover door, pull the FUSE PULL lever and rotate to left. Remove the fuse.
2. Remove the Line Voltage Selection Card. Position the card so the line voltage appears at top-left cover. Push the card firmly into the slot.
3. Rotate the Fuse Pull lever to its normal position. Insert a fuse of the correct value in the holder. Close the cover door.

WARNING

To avoid the possibility of hazardous electrical shock, do not operate this instrument at line voltages greater than 126.5 Vac with line frequencies greater than 66 Hz (leakage currents at these line settings may exceed 3.5 mA).

Figure 2-2. Line Voltage Selection

2-9. Interconnections

The Power Meter and a power sensor are integral parts of this measurement system. Before measurements can be performed, the Power Meter and sensor must be connected together with the power sensor cable. (The cable is supplied with the Power Meter.)

The power sensor cable couples the dc supply and sampling gate drive from the Power Meter to the power sensor and the 220 Hz ac output signal from the power sensor to the Power Meter.

CAUTION

The maximum voltage which may be safely coupled to the Power Meter input from the power sensor is 18 mVrms.

2-10. Operating Environment

The operating environment should be within the following limitations:

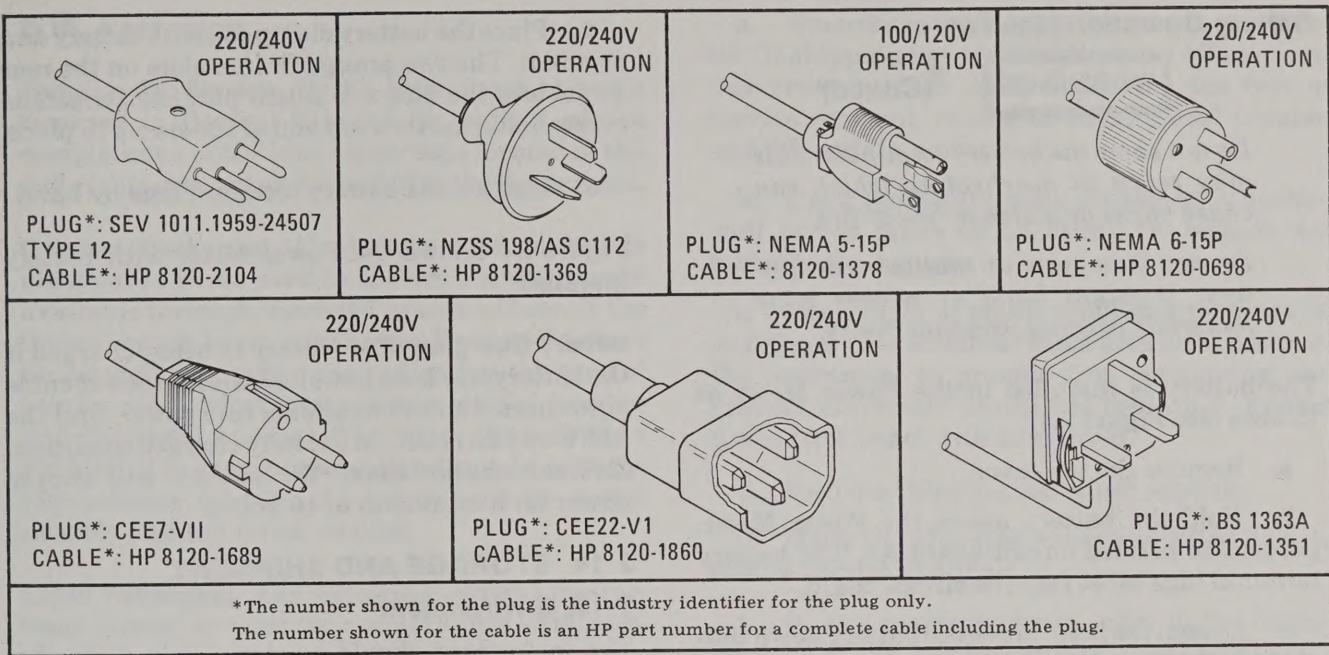


Figure 2-3. Power Cable HP Part Numbers Versus Mains Plugs Available

Operating Environment (cont'd)

Temperature .... 0 to 55°C
Humidity .... <95% relative at 40°C
Altitude .... <4570 metres (15 000 feet)

2-11. Bench Operation

The instrument cabinet has plastic feet and a fold-away tilt stand for convenience in bench operation. (The plastic feet are shaped to ensure self-aligning of the instruments when stacked.) The tilt stand raises the front of the instrument for easier viewing of the control panel.

2-12. Rack Mounting

Instruments that are narrower than full rack-width may be rack-mounted using Hewlett-Packard adapter frames or combining cases.

Adaptor Frames. Hewlett-Packard accessory adaptor frames are an economical means of rack mounting instruments that are narrower than full rack-width. A set of spacer clamps, supplied with each adaptor frame, permits instruments of different dimensions to be combined and rack mounted as a unit. Accessory blank panels are available for filling unused spaces.

Combining Cases. Model 1051A and 1052A Combining Cases are metal enclosures that allow combinations of one-third and one-half rack-width instruments to be assembled for use on a work-bench or for mounting in a rack of standard 19-inch spacing. Each case includes a set of partitions for positioning and retaining instruments and a rack mounting kit. No tools are required for installing the partitions. For bench use the cases have the same convenient features as full rack-width instruments, (i.e., fold-away tilt stands and specially designed feet for easier instrument stacking). Accessories available for the combining cases include blank filler panels and snap-on full width control panel covers.

2-13. Battery Operation

To operate the Power Meter on battery power, the battery must be installed and charged, the line power cable must be disconnected, and the LINE switch must be ON.

Battery Installation.

WARNINGS

This task should be performed only by service trained persons who are aware of the potential shock hazard of working on an instrument with protective covers removed.

To avoid hazardous electrical shock, the line (Mains) power cable should be disconnected before attempting to install the battery.

Battery Operation (Cont'd)

WARNINGS (Cont'd)

Do not short the battery terminals. This may result in overheating which can cause burns or increase risk of fire.

Do not incinerate or mutilate the battery. It might burst or release toxic materials causing personal injury.

The battery is installed in the Power Meter as follows (see Figure 2-4):

a. Remove the top cover.

b. Hold the battery above the Power Meter, parallel to printed circuit board A4. The battery terminal lugs must face the circuit board.

c. Loosen the lugs. Move the battery down into place and guide the lugs into the slots on the circuit board. The battery should now rest on the aluminum deck.

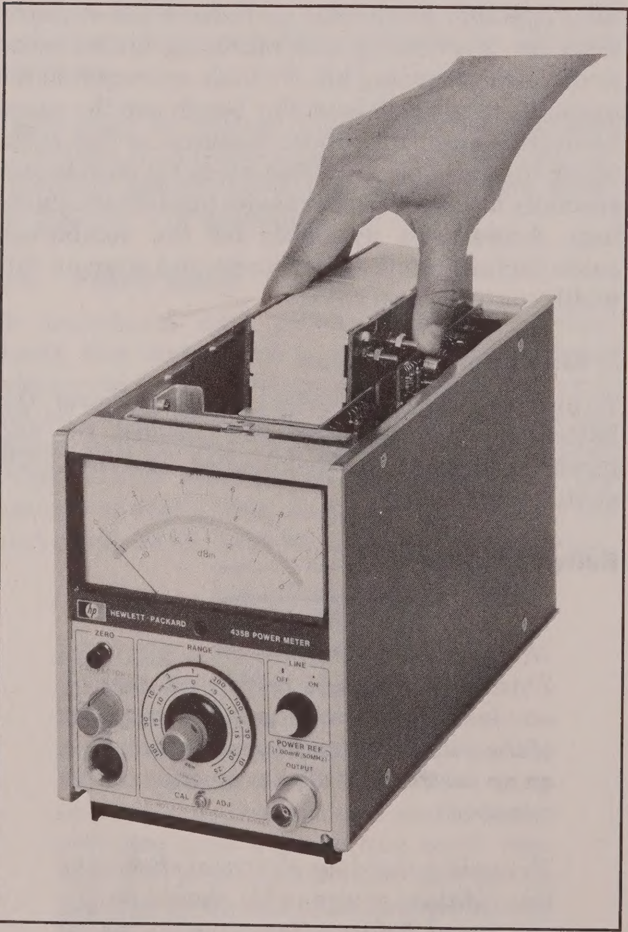


Figure 2-4. Battery Installation

d. Place the battery clamp over the battery and secure it. The two prongs fit into slots on the rear panel and the 6-32 x 1/2-inch pan head machine screw holds the forward end of the clamp in place.

e. Tighten the battery terminal lugs by hand.

Figure 2-5 shows the Power Meter with battery installed.

Battery Charging. The battery is being charged if the battery has been installed, the line power cable is connected to the available line power, and the LINE switch is ON. In the fully charged condition, (24-hour charge time), the battery will supply power for a minimum of 16 hours.

2-14. STORAGE AND SHIPMENT

2-15. Environment

The instrument should be stored in a clean, dry environment. The following environmental limitations apply to both storage and shipment:

Temperature .... –55 to +75°C
Humidity .... <95% relative at 40°C
Altitude .... <15 300 metres (50 000 feet)

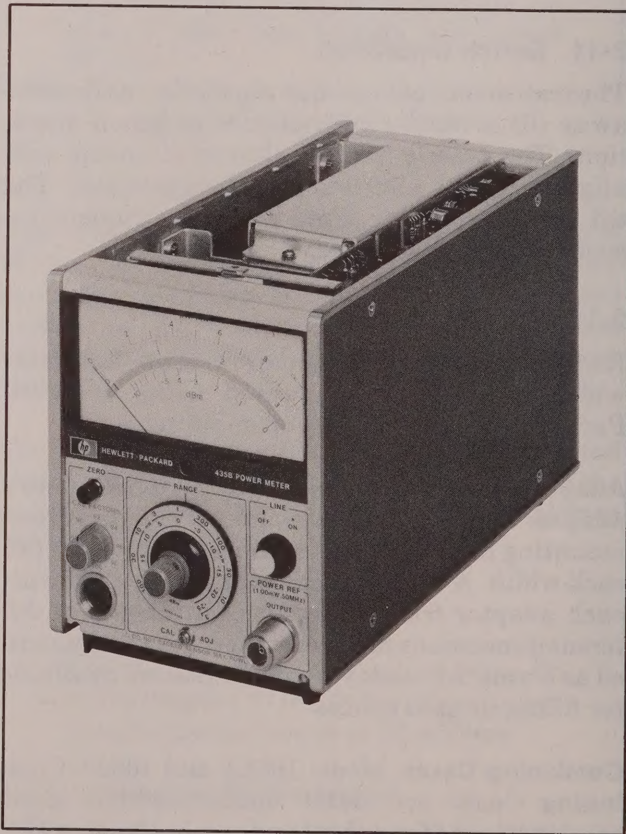


Figure 2-5. Power Meter with Battery Installed

2-16. Packaging

Tagging for Service. If the instrument is being returned to Hewlett-Packard for service, please complete one of the blue repair tags located at the end of this manual and attach it to the instrument.

Original Packaging. Containers and materials identical to those used in factory packaging are available through Hewlett-Packard offices. If the instrument is being returned to Hewlett-Packard for servicing, attach a tag indicating the type of service required, return address, model number and full serial number. Also mark the container FRAGILE to ensure careful handling. In any correspondence refer to the instrument by model number and full serial number.

Other Packaging. The following general instructions should be used for re-packaging with commercially available materials:

a. Wrap the instrument in heavy paper or plastic. (If shipping to a Hewlett-Packard office or service center, attach a tag indicating the type of service required, return address, model number and full serial number.)

b. Use a strong shipping container. A double-wall carton made of 2.4 MPa (350 pound) test material is adequate.

c. Use a layer of shock-absorbing material 70 to 100 mm (3 to 4 inches) thick around all sides of the instrument to provide firm cushioning and prevent movement inside the container. Protect the control panel with cardboard.

d. Seal the shipping container securely.

e. Mark the shipping container FRAGILE to ensure careful handling.

f. In any correspondence, refer to the instrument by model number and full serial number.

SECTION III
OPERATION

3-1. INTRODUCTION

This section provides complete operating instructions for the Power Meter. The instructions consist of: panel features, operator's checks, operating instructions, power measurement accuracy and operator's maintenance.

3-2. PANEL FEATURES

Front and rear panel features of the Power Meter are described in Figures 3-1 and 3-2. These figures contain a detailed description of the controls, indicators and connectors.

3-3. OPERATOR'S CHECKS

NOTE

If the instrument does not operate properly and is being returned to Hewlett-Packard for service, please complete one of the blue repair tags located at the end of this manual and attach it to the instrument.

Upon receipt of the instrument, or to check the Power Meter for an indication of normal operation, follow the operational procedure shown in Figure 3-3. These procedures are designed to familiarize the operator with the Power Meter and to provide an understanding of the operating capabilities.

3-4. OPERATING INSTRUCTIONS

General operating instructions are contained in Figure 3-4. The instructions will familiarize the operator with the basic practices used when operating the Power Meter.

WARNING

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnecting the protective earth terminal is likely to make this instrument dangerous. Intentional interruption is prohibited.

3-5. POWER MEASUREMENT ACCURACY

A power measurement is never free from error or uncertainty. Any RF system has RF losses, mismatch losses, mismatch uncertainty, instrumentation uncertainty and calibration uncertainty. Measurement errors as high as 50% are not only possible, they are highly likely unless the error sources are understood and, as much as possible, eliminated.

3-6. Sources of Error and Measurement Uncertainty

RF Losses. Some of the RF power that enters the power sensor is not dissipated in the power sensing elements. This RF loss is caused by dissipation in the walls of waveguide power sensors, in the center conductor of coaxial power sensors, in the dielectric of capacitors, connections within the sensor and radiation losses.

Mismatch. The result of mismatched impedances between the device under test and the power sensor is that some of the power fed to the sensor is reflected before it is dissipated in the load. Mismatches affect the measurement in two ways. First, the initial reflection is a simple loss and is called mismatch loss. Second, the power reflected from the sensor mismatch travels back up the transmission line until it reaches the source. There, most of it is dissipated in the source impedance, but some of it is re-reflected by the source mismatch. The re-reflected power returns to the power sensor and adds to, or subtracts from, the incident power. For all practical purposes, the effect the re-reflected power has upon the power measurement is unpredictable. This effect is called mismatch uncertainty.

Instrumentation Uncertainty. Instrumentation uncertainty describes the ability of the metering circuits to accurately measure the dc output from the power sensor's power sensing device. In the Power Meter, this error is less than ±1%.[1] It is important to realize, however, that a 1% meter does not automatically give 1% overall measurement accuracy.

Power Reference Uncertainty. The uncertainty of the output level of the power reference oscillator is ±0.7%. This reference is normally used to calibrate the system and is, therefore, a part of the system's total measurement uncertainty.

[1] Refer to Instrument accuracy specification in Section I when using the top two ranges.

Cal Factor Switch Resolution Error. The resolution of the CAL FACTOR switch contributes a significant error to the total measurement because the switch has 1% steps. The maximum error possible in each position is ±0.5%.

3-7. Corrections for Error

Calibration Factor and Effective Efficiency. The two correction factors basic to power meters are calibration factor and effective efficiency. Effective efficiency is the correction factor for RF losses within the power sensor. Calibration factor takes into account the effective efficiency and mismatch losses.

Calibration factor is expressed as a percentage with 100% meaning the power sensor has no losses. Normally the calibration factor will be 100% at 50 MHz, the operating frequency of the internal reference oscillator.

The power sensors used with the Power Meter have individually calibrated calibration factor curves placed on their covers. To correct for RF and mismatch losses, simply find the power sensor's calibration factor at the measurement frequency from the curve or the table that is supplied with the power sensor, and set the CAL FACTOR switch to this value.

The CAL FACTOR switch resolution error of ±0.5% may be reduced by one of the following methods:

1) Set the CAL FACTOR switch to the nearest positions above and below the correction factor given on the table. Interpolating between the power levels measured provides the corrected power level.

2) Leave the CAL FACTOR switch on 100% after calibration. Then, make the measurement and record the reading. Use the reflection coefficient, magnitude and phase angle, if such a table is supplied with the power sensor, to calculate the corrected power level.

3-8. Calculating Worst Case Uncertainty

Worst case uncertainty is the sum of the specified uncertainties and mismatch uncertainty. Uncertainty calculation is outlined in the following two subsections and examples are worked out in Figures 3-5 and 3-6. For a more complete explanation of measurement uncertainty refer to HP application note AN-64-1 "Fundamentals of RF and Microwave Power Measurement".

Specified Uncertainties. The specified uncertainties which account for part of the total power measurement uncertainty are:

a. Instrumentation ±1%[1] or ±0.05 dB.

b. Power reference ±0.7% or ±0.03 dB.

c. CAL FACTOR switch resolution, 0 to ±0.5% (depending on Cal Factor).

d. Zero set, ±0.5% of full scale of lowest range which is 15 nW.

e. Zero Carryover, ±0.5%.

f. Noise and Drift, depends on the range and type of sensor.

g. Calibration factor uncertainty, which depends on sensor type, is listed in the sensor manual.

Figure 3-5 gives an example of specified uncertainty calculation.

Calculating Mismatch Uncertainty. Mismatch uncertainty is the result of the source mismatch interacting with the power sensor mismatch. The magnitude of uncertainty is related to the magnitudes of the source and power sensor reflection coefficients, which can be calculated from SWR. Figure 3-6 shows how the calculations are made and Figure 3-7 illustrates mismatch uncertainty and total calculated uncertainty for two cases. In the first case, the power sensor's SWR = 1.5, and in the second case, the power sensor's SWR = 1.25. In both cases the source has an SWR of 2.0. The example shows the effect on power measurement accuracy a poorly matched power sensor will have as compared to one with low mismatch.

A faster, easier way to find mismatch uncertainty is to use the HP Mismatch Error (uncertainty) Limits/Reflectometer Calculator. The calculator may be obtained, on request, from your nearest Hewlett-Packard office by using HP part number 5952-0948.

The method of calculating measurement uncertainty from the uncertainty in dB is shown by Figure 3-8. This method would be used when the initial uncertainty calculations were made with the Mismatch Error/Reflectometer Calculator.

[1] Refer to Instrument accuracy specification in Section I when using the top two ranges.

3-9. OPERATOR'S MAINTENANCE

The only maintenance responsibilities the operator should normally perform are primary power fuse replacement, LINE switch lamp replacement and rechargeable battery replacement.

Battery replacement is the only operation that requires tools. A Pozidriv screwdriver is needed to remove the battery clamp.

3-10. Fuses

The primary power fuse is found within the A6 Power Module Assembly on the Power Meter's rear panel. For instructions on how to change the fuse, refer to the paragraph entitled Line Voltage Selection in Section II.

CAUTION

Make sure that only fuses with the required rated current and of the specified type (slow blow, time delay, etc.) are used for replacement. The use of repaired fuses and the short-circuiting of fuse-holders must be avoided.

3-11. Lamp Replacement

The lamp is contained in a plastic lens which doubles for a pushbutton on the LINE switch. When the Power Meter LINE switch is ON and is being operated by the available line power, the lamp should be illuminated. If the lamp is defective, remove the lens by pulling it straight out. Order lamp (3131-0434) CD6 and replace the old pushbutton-lamp assembly with the new one. To replace the assembly, align the pins with the notch in the receptacle and push straight in.

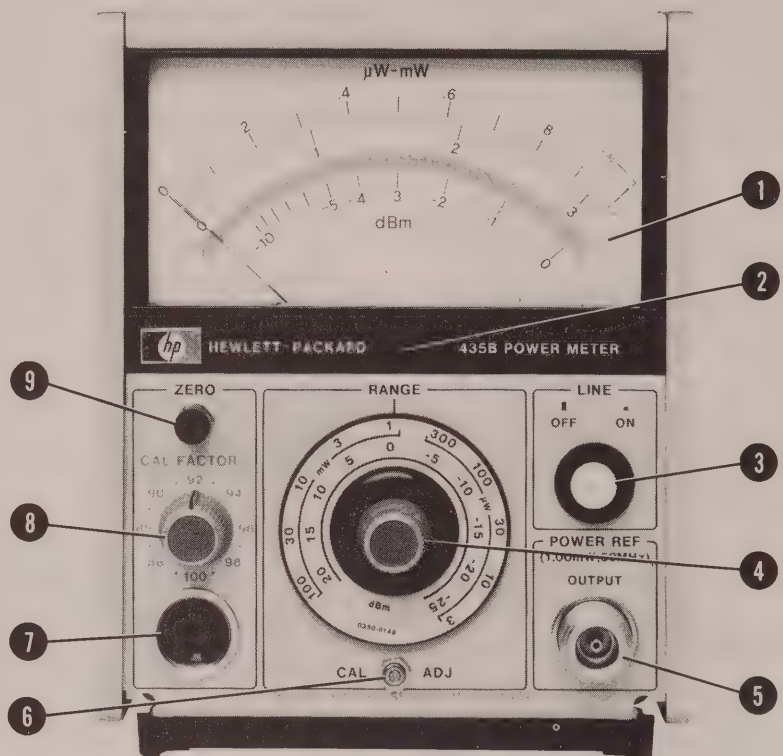
3-12. Battery Replacement

If the meter indicates that the battery is discharged by a full downscale reading, and after charging the battery still will only power the Power Meter for a short period of time, the battery is probably defective. The replacement battery, BT1 (HP part number 1420-0096), may be ordered through the nearest Hewlett-Packard office. Refer to Battery Installation in Section II.

WARNING

This task should be performed only by service trained persons who are aware of the potential shock hazard of working on an instrument with protective covers removed.

FRONT PANEL FEATURES



1 **Meter.** Normally indicates average RF power in dBm or Watts. During battery operation the meter continuously indicates battery condition. A normal reading indicates the battery is charged; a full down-scale reading indicates the battery is discharged or is defective.

2 **Meter Zero.** Mechanical adjustment used to zero the meter when the LINE switch is OFF.

3 **LINE Switch.** Connects line or battery power to the Power Meter circuits when the LINE switch is ON. During battery operation, the lamp contained within the LINE switch will not be illuminated when the INSTRUMENT is ON.

4 **RANGE Switch.** Selects desired power range; keyed to meter full-scale deflection; has three removable scales which are changed to match the range of the power sensor.

5 **POWER REF OUTPUT.** RF output of 1.00 mW ±0.70% into 50Ω at 50 MHz from an internal reference oscillator. Available for system calibration.

6 **CAL ADJ.** Screwdriver adjustment for calibrating any power sensor and Power Meter as a system, to a known standard.

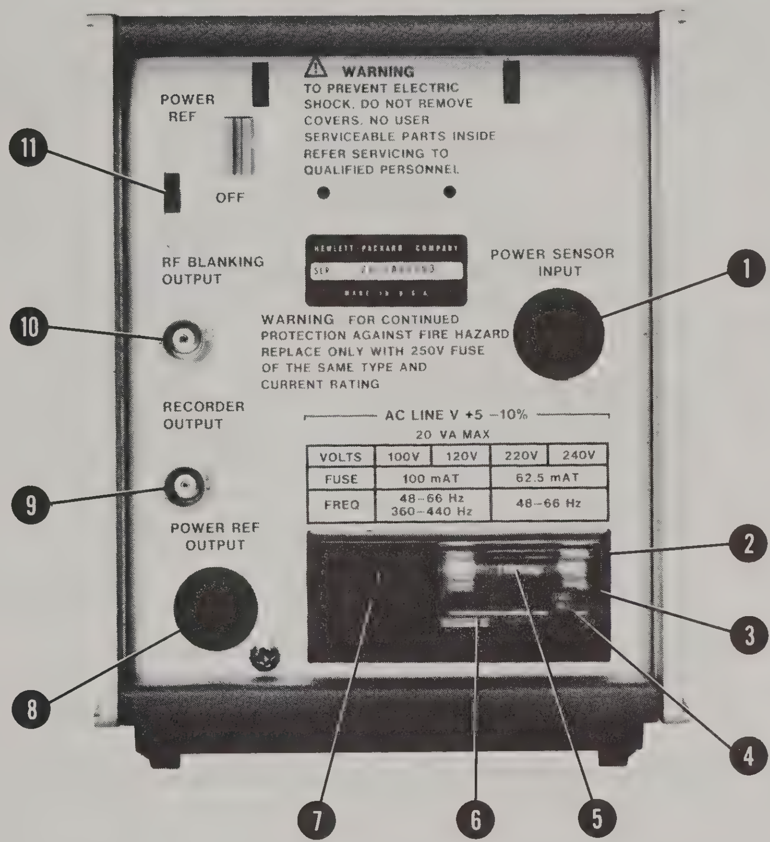
7 **Input Connector.** Input from the power sensor via the power sensor cable.

8 **CAL FACTOR Switch.** Changes the gain of the Power Meter amplifier circuits to compensate for mismatch losses and effective efficiency of the power sensor.

9 **ZERO Switch.** The ZERO switch activates a feedback circuit, which automatically zeros the meter pointer, and a rear panel RF blanking signal.

Figure 3-1. Front Panel Controls, Connectors and Indicators

REAR PANEL FEATURES



1 POWER SENSOR INPUT. Option 002 has a rear panel input connector wired in parallel with the front panel input connector. In Option 003, this connector replaces the input front panel connector.

2 Power Module Assembly.

3 Window. Safety interlock; fuse cannot be removed while power cable is connected to Power Meter.

4 FUSE PULL Handle. Mechanical interlock to guarantee fuse has been removed before Line Voltage Selection Card can be removed.

5 Fuse. Refer to Section II for values.

6 Line Voltage Selection Card. Matches transformer primary to available line voltage.

7 Receptacle. For power cable connection to available line voltage.

8 POWER REF OUTPUT. Takes the place of the front panel POWER REF OUTPUT connector (Option 003 only).

9 RECORDER OUTPUT. Provides a linear output with respect to the input power. +1.00 Vdc corresponds to meter full-scale. The minimum load which may be coupled to the output is 1 MΩ.

10 RF BLANKING OUTPUT. Contact closure to ground when ZERO switch is pressed. May be used to remove RF input signal during automatic zeroing operation.

11 POWER REF Switch. Opens or closes the circuit from the power supply to the power reference oscillator. Reduces current drain during battery operation when OFF.

Figure 3-2. Rear Panel Controls, Connectors and Indicators

OPERATOR'S CHECKS

1. BEFORE SWITCHING ON THIS INSTRUMENT, check that the power transformer primary is matched to the available line voltage, the correct fuse is installed and the safety precautions are taken. See Power Requirements, Line Voltage Selection, Power Cables and associated warnings and cautions in section II.

WARNINGS

BEFORE CONNECTING LINE POWER TO THIS INSTRUMENT, ensure that all devices connected to this instrument are connected to the protective (earth) ground.

BEFORE SWITCHING ON THIS INSTRUMENT, ensure that the line power (Mains) plug is connected to a three-conductor line power outlet that has a protective (earth) ground. (Grounding one conductor of a two-conductor outlet is not sufficient.)

CAUTION

Do not twist the body of the power sensor when connecting or disconnecting it. This can cause major damage to the power sensor.

2. Set the meter indication to zero with the mechanical meter zero control. Back the control off slightly.

3. Connect the power sensor to the Power Meter with the power sensor cable.

4. Connect the power cable to the power outlet and power module receptacles. Set the LINE switch to ON; the lamp within the switch lens should be illuminated.

5. Change the Power Meter's RANGE switch scale so it corresponds to the range of the power sensor. Refer to the paragraph entitled Range Switch Scale Selection in Section II.

6. Set the Power Meter Controls as follows:

   RANGE switch position...........fully ccw
   CAL FACTOR switch.............100%
   POWER REF switch..............OFF

7. Press the ZERO switch and verify that the meter pointer moves to zero (0) and the RF BLANKING OUTPUT is shorted to ground.

8. Set the RANGE switch to the position indicated in the following table. Then, connect the power sensor (and adapter or attenuator as required) to the POWER REF OUTPUT and set the rear panel POWER REF switch to (ON). Verify that the meter reads approximately the same as indicated in the table.

Figure 3-3. Operator's Checks (1 of 2)

OPERATOR'S CHECKS

Power Sensor	RANGE Switch Position	Meter Indication
8481B and 8482B (remove attenuator)	3W	1W
8481A, 8482A, 8481H, 8482H	3 mW	1 mW
8485A (HP 1250-1250 Adapter required)	3 mW	1mW
8483A (HP 1250-0597 Mechanical Adapter required)	3 mW	0.96 mW
8484A (HP 11708A Reference Attenuator rrequired)	3 μW	1 μW

9. Step the CAL FACTOR switch through its range noting a small increase in meter reading with each successive step. Reset the CAL FACTOR switch to 100%.

10. Set the RANGE switch to the position indicated in the table below. Then, adjust the CAL ADJ control for a full-scale meter reading for 50Ω power sensors and a 96% of full scale meter reading for 75Ω power sensors.

Power Sensor	RANGE Switch Position
8481B and 8482B (remove attenuator)	1W
8481A, 8482A, 8481H, 8482H	1 mW
8485A (HP 1250-1250 Adapter required)	1 mW
8483A (HP 1250-0597 Mechanical Adapter required)	1 mW
8484A (HP 11708A Reference Attenuator required)	1 μW

11. Check at the rear panel RECORDER OUTPUT jack for an output of ≈ 1 Vdc.

12. To check operation using battery power, disconnect the power cable from the rear panel power module receptacle and set the LINE switch to ON (the lamp within the switch lens will not be illuminated). When a power measurement is made, a normal upscale reading indicates normal operation; a full down-scale reading indicates the battery is discharged.

Figure 3-3. Operator's Checks (2 of 2)

OPERATING INSTRUCTIONS

1. BEFORE SWITCHING ON THIS INSTRUMENT, check that the power transformer primary is matched to the available line voltage, the correct fuse is installed and safety precautions are taken. See Power Requirement, Line Voltage Selection, Power Cables and associated warnings and cautions in Section II.

WARNINGS

BEFORE CONNECTING LINE POWER TO THE INSTRUMENT, ensure that all devices connected to this instrument are connected to the protective (earth) ground.

BEFORE SWITCHING ON THIS INSTRUMENT, ensure that the line power (Mains) plug is connected to a three-conductor line power outlet that has a protective (earth) ground. (Grounding one conductor of a two-conductor outlet is not sufficient.)

CAUTION

Do not twist the body of the power sensor when connecting or disconnecting it. This can cause major damage to the sensor.

2. Set the meter indication to zero with the mechanical meter zero control. Back the control off slightly.

3. Connect the power sensor to the Power Meter with the power sensor cable.

4. Connect the power cable to the power outlet and power module receptacles. Set the LINE switch to ON; the lamp within the switch lens should be lit.

5. Change the Power Meter's RANGE switch scale so it corresponds to the range of the power sensor. Refer to the paragraph entitled Range Switch Scale Selection in Section II.

6. Set the Power Meter switches as follows:

   RANGE position .... fully ccw
   CAL FACTOR 100%
   POWER REF .... OFF

7. Press the ZERO switch, allow 5 seconds for the zeroing operation to take place, and release the switch.

8. Set the RANGE switch to the position indicated in the following table. Then, connect the power sensor (and adapter or attenuator as required) to the POWER REF OUTPUT and set the rear panel POWER REF switch to (ON). For 50Ω power sensors, adjust the CAL ADJ control for a full-scale reading; the meter pointer should be aligned with the CAL mark (full-scale reading) on the meter face. For 75Ω power sensors, adjust the CAL ADJ control for a 96% of full scale reading; the meter pointer should be aligned with the 0.96 mark on the meter face.

Figure 3-4. Operating Instructions (1 of 2)

OPERATING INSTRUCTIONS

Power Sensor	RANGE Switch Position
8481B and 8482B (remove attenuator)	1W
8481A, 8482A, 8481H, 8482H	1 mW
8485A (HP 1250-1250 Adapter required)	1 mW
8483A (HP 1250-0597 Mechanical Adapter required)	1 mW
8484A (HP 11708A Reference Attenuator required)	1 μW

9. Disconnect the power sensor from the POWER REF OUTPUT and set the POWER REF switch to OFF.

10. Locate the calibration curve on the power sensor cover. Find the CAL FACTOR for the measurement frequency; set the CAL FACTOR switch accordingly.

11. Set the RANGE switch such that full scale is greater than the power level to be measured.

CAUTION

See Operating Precautions in the power sensor Operating and Service Manuals for maximum power levels which may be safely coupled to this system. Levels which exceed the limits may damage the power sensor, Power Meter, or both.

12. Connect the power sensor to the RF source. Read the power level in dBm or Watts on the panel meter.

NOTE

When the battery is being used as the power supply for the Power Meter, an automatic test circuit continually monitors battery condition. When the battery voltage is above a predetermined level, the meter indicates the correct power level. When the voltage drops below the threshold level, the meter reading is full downscale.

Figure 3-4. Operating Instructions (2 of 2)

SPECIFIED UNCERTAINTY CALCULATION

Conditions: Range — 1 mW
Meter Reading — 0.7 mW
Sensor — 8481A
Frequency — 1 GHz
CAL FACTOR — 99.5%

(FS)	Instrumentation Uncertainty	= ±1.0%	= ±0.01 mW	= ±0.06 dB
(R)	Power Reference Uncertainty	= ±0.7%	= ±0.0049 mW	= ±0.03 dB
(R)	CAL FACTOR Switch Resolution Uncertainty	= ±0.5%	= ±0.0035 mW	= ±0.02 dB
(R)	Zero Set Uncertainty	= ±0.002%	= ±0.000015 mW	= ±0.00009 dB
(FS)	Zero Carryover Uncertainty	= ±0.5%	= ±0.005 mW	= ±0.03 dB
(R)	Noise	= ±0.006%	= ±0.00004 mW	= ±0.00025 dB
(R)	Drift	= ±0.002%	= ±0.000015 mW	= ±0.00009 dB
(R)	Cal Factor Uncertainty	= ±2.70%	= ±0.019 mW	= ±0.12 dB
			±0.0425 mW	

$$\text{Total Specified Uncertainties} = \pm 0.0425\ \text{mW} = \frac{0.0425}{0.7}(100) = \pm 6.07\%$$

$$= 10 \log \frac{0.7425}{0.7} = \pm 0.26\ \text{dB}$$

NOTE: FS = % of full scale
R = % of reading

Figure 3-5. Specified Uncertainties

CALCULATING MEASUREMENT UNCERTAINTY

1. Calculate the reflection coefficient from the given SWR.

$$\rho = \frac{SWR-1}{SWR+1}$$

Power Sensor #1	Power Sensor #2	Power Source
SWR = 1.5	SWR = 1.25	SWR = 2.0
$\rho_1 = \frac{1.5-1}{1.5+1}$	$\rho_2 = \frac{1.25-1}{1.25+1}$	$\rho_S = \frac{2.0-1}{2.0+1}$
$= \frac{0.5}{2.5}$	$= \frac{0.25}{2.25}$	$= \frac{1.0}{3.0}$
= 0.2	= 0.111	= 0.333

2. Calculate the relative power and percentage power mismatch uncertainties from the reflection coefficients. An initial reference level of 1 is assumed.

Relative Power Uncertainty

$$PU = [1 \pm (\rho_n \rho_S)]^2$$

$$\begin{aligned} PU_1 &= \{1 \pm [(0.2)(0.333)]\}^2 \\ &= \{1 \pm 0.067\}^2 \\ &= \{1.067\}^2 \text{ and } \{0.933\}^2 \\ &= 1.138 \text{ and } 0.871 \end{aligned}$$

$$\begin{aligned} PU_2 &= \{1 \pm [(0.111)(0.333)]\}^2 \\ &= \{1 \pm 0.037\}^2 \\ &= \{1.037\}^2 \text{ and } \{0.963\}^2 \\ &= 1.075 \text{ and } 0.927 \end{aligned}$$

Percentage Power Uncertainty

$\%PU = (PU-1)\ 100\%$

$\%PU_1 =$	(1.138—1) 100%	and	(0.871—1) 100%
=	(0.138) 100%	and	(—0.129) 100%
=	13.8%	and	—12.9%
$\%PU_2 =$	(1.075—1) 100%	and	(0.927—1) 100%
=	(0.075) 100%	and	(—0.073) 100%
=	7.5%	and	—7.3%

Figure 3-6. Calculating Measurement Uncertainties (1 of 2)

CALCULATING MEASUREMENT UNCERTAINTY

3. Calculate the Measurement Uncertainty in dB.

$$MU = 10\left[\log_{10}\left(\frac{P_1}{P_0}\right)\right] \text{ dB}$$

$$MU_1 = 10\left[\log\left(\frac{1.138}{1}\right)\right] \quad \text{and} \quad 10\left[\log\left(\frac{0.871}{1}\right)\right]$$

$$= 10\,[0.056] \quad \text{and} \quad 10\,[-0.060]$$

$$= +0.56 \text{ dB} \quad \text{and} \quad -0.60 \text{ dB}$$

$$MU_2 = 10\left[\log\left(\frac{1.075}{1}\right)\right] \quad \text{and} \quad 10\left[\log\left(\frac{0.927}{1}\right)\right]$$

$$= 10\,[0.031] \quad \text{and} \quad 10\,[-0.033]$$

$$= +0.31 \text{ dB} \quad \text{and} \quad -0.33 \text{ dB}$$

Figure 3-6. Calculating Measurement Uncertainties (2 of 2)

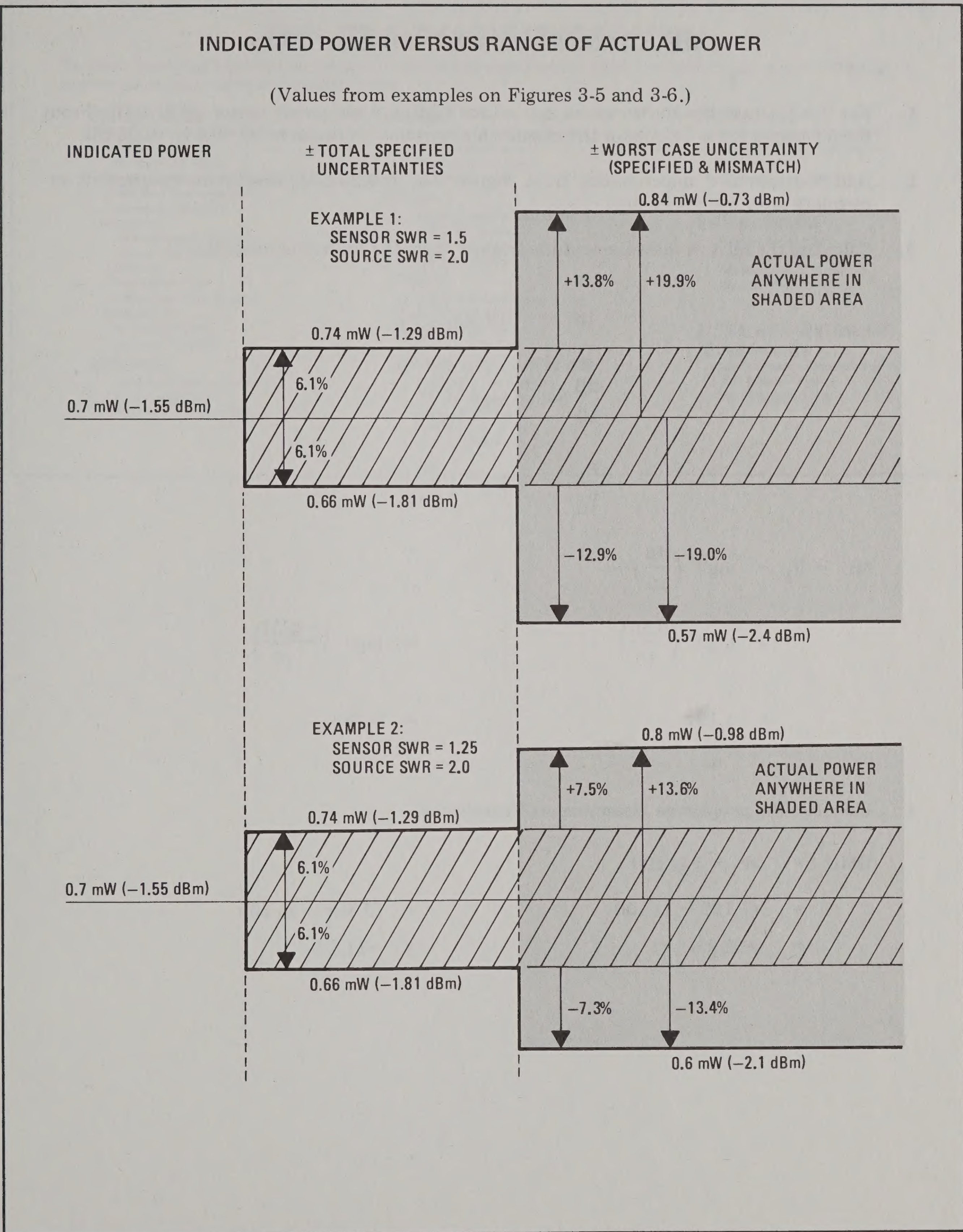


Figure 3-7. Worst Case Effects of Specified and Mismatch Uncertainties

CALCULATING MEASUREMENT UNCERTAINTY

1. For this example the known values are: source SWR, 2.2 and power sensor SWR, 1.16. From the Mismatch Error Calculator the mismatch uncertainty is found to be +0.24, —0.25 dB.

2. Add the specified uncertainties from Figure 3-5, (±0.26 dB). Our total measurement uncertainty is +0.50, —0.51 dB.

3. Calculate the relative measurement uncertainty from the following formula:

$$dB = 10 \log\left(\frac{P_1}{P_0}\right)$$

$$\frac{dB}{10} = \log\left(\frac{P_1}{P_0}\right)$$

$$\frac{P_1}{P_0} = \log^{-1}\left(\frac{dB}{10}\right)$$

$$MU = P_1 = \log^{-1}\left(\frac{dB}{10}\right)$$

$$= \log^{-1}\left(\frac{0.50}{10}\right) \qquad = \log^{-1}\left(\frac{-0.51}{10}\right)$$

$$= 1.122 \qquad = 0.889$$

4. Calculate the percentage Measurement Uncertainty.

$$\%MU = (P_1 - P_0)\,100$$

$$= (1.122 - 1)\,100 \qquad = (0.889 - 1)\,100$$

$$= +12.2\% \qquad = -11.1\%$$

Figure 3-8. Calculating Measurement Uncertainty (Uncertainty in dB Known)

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